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SUPPORT FOR THE REDUCTION OF
HIPPARCOS COORDINATE SYSTEM DATA
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HIPPARCOS COORDINATE SYSTEM DATA

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The following report was in application for continuation of the above grant. The application was accepted, but because of administrative delays, a new grant was issued to continue the work. The new grant was NAGW-3111. The continuation of the work has led to the successful beginning of HST observations for this project in 1993, and the continuation of those observations throughout the first year of observation. The Hipparcos satellite was turned off in 1993, having obtained sufficient data to fulfill its mission. The data reduction will continue through the end of 1995, and the final catalogue will be released in 1996. To date we have obtained more than fifty measurements of Hipparcos star-Extragalactic Object pairs with the HST Fine Guidance Sensors. These data will be used to help tie the Hipparcos reference frame to the extragalactic frame at the milliarcsecond level of accuracy, thereby satisfying the first goal of this project.

The purpose of the grant is to provide support for the analysis of HIPPARCOS and related (e.g., HST-Fine Guidance Sensor (FGS), and Wide Field/Planetary Camera (now planned for WFPCII)) data for three HIPPARCOS programs: (1) tying the HIPPARCOS Reference Frame to Extragalactic Objects using HST observations, (2) measuring the motion of a set of minor planets with respect to the HIPPARCOS Frame (also using some HST observations), and (3) determining whether or not the sun is in a local concentration of A and F stars.

Progress During 1991 and Current Status:*HIPPARCOS Status – INCA Status*

HIPPARCOS is collecting data and operating normally. The useful data (being obtained outside the van Allen belts, about 80% of the time) are extremely good; they are better than the pre-launch simulations. The data reduction consortia (FAST and ENDAC) are processing various subsets of the data already obtained to check on consistency and accuracy. Recently (January 1992), the first full sphere solution using more than a full year's worth of data was performed by FAST. The results were 8000 positions and parallaxes (the proper motions were set to the ground determined values) with rms uncertainties of 2.5 milliarcsec or better. More than 9000 binaries have been observed, of which 3500 are new. An initial color-magnitude diagram has been formed which has

superceded all previous color-magnitude diagrams determined for field stars.

The Input Catalogue of stellar data for the HIPPARCOS mission is complete and is being ready for publication. As of this writing (April 1992) the catalogue should be available in printed form in a few weeks. A magnetic tape version should also be available soon. Discussions are ongoing about a CD version.

HST FGS Changes and Preparation for Data Reduction

Milliarcsecond astrometry cannot begin until the secondary mirror's final position has been determined and a minimum amount of calibration has been performed. Every time the secondary mirror is moved, the field distortions change. During the year from December 1990 to December 1991, the position of the secondary mirror of HST was moved many times in "tilt" and "decenter" to determine the position which optimized the off axis aberrations in all of the instruments. During these moves, varying degrees of degradation in the FGS interferometric transfer function were observed in various parts of the FGS fields of view ("pickles"). Detailed modeling of the FGS optical paths has lead to the conclusion that off-axis aberrations such as coma and astigmatism, in the presence of the main spherical aberration, can account for the degraded "S-curves". Initially, these observations led to the conclusion that the limiting magnitude of the FGSs would be severely restricted compared with the initial expectations. Because of this expectation, discussions were held at the IAU in Buenos Aires in July 1991 with the HIPPARCOS working group on the radio-optical tie, with the conclusion that a search should be undertaken to identify more bright extragalactic (EGO)-HIPPARCOS Star pairs, even if the EGOs were not necessarily radio emitters. In November, a final set of observations were obtained, and in early December, the secondary mirror position was determined. In December (1991) the HST Astrometry Team began the calibration of the FGSs for astrometry. The limiting magnitude in FGS3, the FGS of choice for astrometry, has been shown to be of the order of 17th magnitude in the center of the pickle, so the impact on the HIPPARCOS tie is not as severe as first thought.

However, during the previous year, some inconsistencies in the field distortion model had been detected at different secondary mirror settings, so measurements were performed on the same star field in the same orientation at the same secondary mirror position on the same date as an identical set the year before. The fit of one data set to the other (December 1990 to December 1991) showed large and systematic differences over the pickles amounting to 0.1 arcsec in some cases. The data were taken with Coarse Track guiding, which does not provide the stability or the accuracy of Fine Lock guiding. Hence they are somewhat suspect in terms of providing information about the ability of the FGSs to perform milliarcsecond astrometry. However the shifts observed are real and large and must be understood. The cause of the shifts are not yet known, but they can be modeled at the 10 milliarcsecond level at the present time. Until we have a better understanding of this phenomenon, FGS astrometry is on "hold". However, we are observing a "standard" field periodically (about once every 2 weeks) to monitor the geometric stability of the FGS distortions. Initial indications over the first 30 days are that the field is repeatable at the 1-mas level (rms). If this trend continues, we hope to proceed with FGS astrometry in the

near (months) future.

Meanwhile, Noel Argue and Graeme White at Cambridge, England searched existing catalogues for bright EGOs suitable for the HIPPARCOS reference frame program. These new objects have been incorporated into the GO/GTO HST program to tie the HIPPARCOS frame to EGOs. The application for GO time in Cycle 2 to make the HST observations was awarded all the time requested, (40 hours/year for 3 years).

IAU

In July and August, Hemenway attended the IAU General Assembly in Buenos Aires, Argentina. In the absence of the Chairman, Noel Argue, he chaired a meeting of the HIPPARCOS Working Group 2130, "Linking the HIPPARCOS reference frame to extragalactic objects". The main discussion centered around the way to make maximum use of the HST observations if the limiting magnitude were as bright as 15th. (See above.) Hemenway also presented a paper to a joint meeting of Commissions 24 and 8 on the status of the HIPPARCOS Tie project.

Most of the work on this grant has concentrated on the HIPPARCOS-Extragalactic Object Tie, because that part of the project is directly involved in the formation of the HIPPARCOS system, and is directly involved in the HIPPARCOS Project itself. We are just beginning to work on the other two HIPPARCOS projects mentioned above. A brief report on each of the projects follows.

GTO/GO Project to Link the HIPPARCOS Reference Frame to an Extragalactic Reference Frame

Working on this grant, graduate student Frank Shattuck of the Aerospace Engineering Department at Texas is writing a Masters Thesis with Hemenway, Duncombe, and Tapley which deals with the reduction of HST and HIPPARCOS and VLBI data to obtain the relative motions of the two reference frames given above. Under the direction of Hemenway, he has designed a software system to obtain the rotation and offset parameters for the above problem, using the GAUSSFIT reduction package of Jefferys and MacArthur. The thesis is scheduled for completion in the Summer, 1992. Hemenway continued close contact with the HIPPARCOS project. Hemenway spent 2 days in Grasse, France, where he discussed the latest HIPPARCOS results with Dr. Kovalevsky. HIPPARCOS appears well on its way to completing its full mission, with 2 mas positions parallaxes and proper motions for 118000 stars. In August, Hemenway and 14 collaborators submitted a Cycle 2 Proposal. The proposal was granted 40 S/C hours per year for 3 years, starting in Cycle 2. Hemenway continues to revise the GTO and GO STScI proposals in light of the final secondary mirror position and the final selection of FGS3 as the astrometer, and in light of changes in the STScI proposal system. The additional bright EGO-HIPPARCOS star pairs identified by Argue and White have been incorporated into the HST proposals. Hemenway continues to serve on the HIPPARCOS Working Group 2130 for Linking HIPPARCOS to the Extragalactic Frame.

When Shattuck's software is completed and tested, we will be able to make a realistic estimate of the accuracy we can expect for the Reference Frame Tie. We will also be in a position to ask for preliminary HIPPARCOS data on the link stars to include in the reductions for analysis of the error contribution from real HIPPARCOS data.

HIPPARCOS Reference Frame and a Dynamical Reference Frame

In order to refine the orbits of the 34 minor planets involved in this project, we need to reduce into the HIPPARCOS System a series of ground-based observations that have been made over the past 14 years, with the highest possible accuracy. Laboratory Research Assistant Noah Smith has been working to increase the accuracy of the reduction of the ground-based data. NONE OF THE GROUND-BASED OBSERVATIONS WERE MADE FROM FUNDS FROM THIS GRANT. However, the reductions are directly relevant to the accurate reduction of the minor planet positions to the HIPPARCOS System, and hence the determination of the relationship between the HIPPARCOS system and the minor planet system defined by those and (projected) HST observations. Duncombe and Hemenway plan to use 40 hours of their GTO time for the minor planet observations.

Partially successful observations of one of the minor planets have already been made with HST for the plate-scale determination of HST. (The measurements were made in "course track" rather than in "fine lock" because of an idiosyncrasy of the system for setting up on a minor planet that we were unaware of when we prepared the observations. The condition is now understood and will be taken into account in future observations. The result was that the minor planet positions measured were about 20 times worse than they would have been if they had been measured in fine lock.) The conclusion from the (test) observations is that we will be able to find and track the minor planets in the project.

A Local Concentration of A and F Stars?

Recent abundance analyses of stars in this spectral range have shown that accurate RELATIVE models of stellar atmospheres may be made which can be used to determine the relative thermodynamic parameters of the atmospheres of these stars from Stromgren and Hb photometry. The HIPPARCOS parallaxes for the nearer stars (within 200 pc) in the sample will provide an absolute calibration for these parameters. The proper motions for the rest will be used for statistical analysis of the clustering problem. We expect a graduate student to begin work on these calibrations, and to prepare for the reduction of real HIPPARCOS data. The HIPPARCOS proper motions of the whole sample will provide information on the nature of the clustering if it exists and the relationship of the sun to the local spiral structure. Abundance analysis of sample stars will provide information about the age, metallicity, and population distribution within the sample.